1,163,364

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,163,364

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COMPLETE SPECIFICATION

Falling Film Evaporator

I, AXEL EVERHARD ROSENBLAD, resident of Princeton, New Jersey, United States of America, a citizen of the United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a falling film evaporator.

According to the invention there is provided an evaporator of the falling film type comprising a plurality of hollow heating elements each comprising two vertical, parallel plates and closed along its entire perimeter, the heating elements being disposed in a row extending perpendicularly to the parallel heating planes of the plates, and providing substantially plane heating surfaces, the confronting heating surfaces of successive heating elements being spaced to provide channels therebetween which are open at both vertical edges of said heating elements, means to supply a liquid to be evaporated to the outer surfaces of the heating elements at the upper edges thereof so that the liquid flows downwardly over the heating surfaces of the plates in the form of continuous films, means to introduce a heating fluid into and to exhaust it from the heating elements, a casing enclosing the heating elements and the liquid supplying means, said casing providing a vapor body at each vertical edge of the heating elements in free communication with the open edges of the respective channels, and means including a conduit opening into each vapor body at a position substantially below the upper ends of said channels for exhausting vapor released from the falling films of liquid from said vapor bodies and causing substantial lateral flow of said vapor out of said channels throughout the full height thereof into said vapor bodies.

The falling film evaporator of the invention is particularly characterized by the fact that the vapors released from the falling films are readily discharged from the evaporator without an appreciable pressure drop. A further feature of the evaporator of the invention is the provision of means whereby the individual heating elements of the evaporator may be readily mounted upon or removed from their feeding and discharge manifolds, whereby the total effective heating area of the evaporator may be changed as required. The casing or housing which surrounds the heating elements may be made with a length which is greater than that required for the initial installation, and the manifolds may be made with lengths sufficient to span the entire length of such alternative casing and with connections thereon for the mounting of additional heating elements in the future, as required.

In prior evaporators of the falling film type, various means have been employed to remove vapor released from the films falling upon the heating surfaces. In my Patent Specification No. 1,033,599 each of the heating channels is shown as closed at one vertical edge so that vapor released from the falling films is discharged only from the other, open vertical edges of the heating channels. This requires some of the vapor to travel across substantially the full width of the heating channels before it is discharged therefrom, and thus adds markedly to the pressure drop imposed upon the vapor as a whole.

In the evaporator according to the present invention, on the other hand, the heating elements are closed along their entire perimeter, and are disposed vertically in parallel spaced relationship, so that the vaporizing channels between the heating elements are open along each of their vertical edges. Thus, at most, vapor released from the falling films must travel a distance of only half the width of the heating elements before they are discharged from the heating channels. In the casing of the evaporator, a vapor receiving space or vapor body is disposed in immediate communication with

[Price 4s. 6d.]

each of the vertical open edges of the vaporising channels, and a vapor discharge conduit is provided for each of the vapor bodies. Thus the overall pressure drop in the released vapor in the evaporator of the present construction is substantially less than that in prior falling film evaporators.

As above indicated, the falling film evaporator of the present invention particularly lends itself to future expansion of the heating surface area as required by later changes in the plant in which it is used. Thus the heating elements and the manifolds to which they are connected are made such that the heating elements may be readily connected to and removed from the manifolds as required. Thus the manifolds may be made longer than is originally required, and may be made to extend throughout the whole length of the casing which may be similarly extended, the number of heating elements initially mounted on the manifolds being less than those which the lengthened casing and manifolds can accommodate.

Embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which like reference characters refer to like parts throughout the several views, and in which:

Fig. 1 is a view in vertical section through one embodiment of a falling film evaporator in accordance with the invention and showing somewhat schematically appurtenant devices connected thereto when the evaporator is used with recompressed vapor as the heating medium therefor, the section through the evaporator being taken generally along the broken section line 1—1 of Fig. 2 looking in the direction of the arrows:

Fig. 2 is a view in vertical section transverse to the section of Fig. 1, the section being taken along the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary view in horizontal section through the upper portion of the evaporator of Figs. 1 and 2, the section being taken along the line 3—3 of Fig. 2 looking in the direction of the arrows;

Fig. 4 is a view in vertical section similar to that of Fig. 1 of a second embodiment of falling film evaporator in accordance with the invention; and

Fig. 5 is a view in horizontal section through the lower part of the apparatus of Figs. 1, 2, and 3, the section being taken along the broken line 5—5 of Fig. 1 looking in the direction of the arrows.

Two embodiments of falling film evaporator are shown herein, the first embodiment generally designated 10 being shown in Figs. 1, 2 and 3, and the second, designated 10^1, being shown in Fig. 4. Fig. 5 shows a portion of the piping employed in both such evaporators. The evaporator 10^1 per se is generally the same as evaporator 10 with the exception that the casing of evaporator 10^1 has been horizontally or longitudinally extended, the heating and discharge manifolds have been correspondingly lengthened, and a longer pipe for supplying the spray nozzles of the liquid distributing means is used. Consequently, the same reference characters for similar parts are employed in Fig. 4 as those in Figs. 1. 2 and 3.

Turning now to the embodiment of Figs. 1—3, inclusive, the evaporator 10 includes a plurality of vertically disposed spaced heating elements 11 which are composed of spaced parallel broad plates 12, pairs of which are connected around their entire peripheries by welding or other means, not specifically shown, whereby to form closed heating spaces within the elements 11. The heating elements 11 are enclosed in a casing generally designated 14, such casing having a right sidewall 15 (Fig. 1), and a left sidewall 16, and similar upwardly inclined end walls 17 (Fig. 2). The heating elements 11 are show laterally centrally mounted within the casing 14, such casing having a width (Fig. 2) which markedly exceeds the width of the elements 11 so as to provide similar vapor receiving spaces or vapor bodies 18 of relatively large dimensions in direct communication with the open vertical edges of the heating channels 23 formed between the spaced apart opposed side walls 12 of successive heating elements 11. The casing is completed by a top wall 19 and a bottom wall 20, thus to form a closed space including the vapor bodies 18 therewithin.

Extending lengthwise along the interior of the casing 14, at a location toward the top thereof are two spaced parallel steam manifolds 22 which are symmetrically disposed relative to the casing as shown in Figs. 2 and 3. The interiors of the heating elements 11 are connected at each of their upper corners to the interior of the respective manifolds 22 by short curved pipes 25, extending upwardly from each heating element. Each of the heating elements 11 is provided laterally, centrally of the bottom thereof, with a condensate discharge pipe 29 which connects it to a horizontal condensate discharge manifold 24. It will be seen that the heating elements 11 are rigid pressure vessels which may be readily disconnected from manifolds 22 and 24 by cutting or disconnecting the respective pipes 25 and 29 and by lifting the disconnected elements out of the casing through an opening (not shown) in the upper wall of the casing from which a cover (not shown) has been removed. The short portions of pipes 25 and 29 may be suitably closed, for example by capping them or by welding them closed, if the evaporator is to be operated with fewer heating elements 11 than the casing and manifolds of the evaporator will accommodate.

Each of the vapor receiving spaces or bodies 18 at a position therein somewhat below the upper end of the channels 23 is provided with a vapor discharge conduit 32 which penetrates

the casing through the wall 15 thereof, as shown in Fig. 1. Thus, as seen by the arrows in Fig. 2, the vapors are drawn out of both vertical sides of the channels 23 throughout the height of those channels rather than being permitted to flow upwardly in contracurrent to the liquid film flowing down the outer surfaces of the heating elements. Conduits 32 are connected by a manifold 33 which is centrally connected to the intake port of a compressor 34. The discharge port of the compressor is connected to a pipe 35 which is centrally connected to a transverse manifold 36, the branches of which are connected to the outer ends of the steam manifolds 22. It will thus be seen that the evaporator of Figs. 1, 2 and 3 is of the recompression heating type, the vapor from the falling films discharged into the vapor bodies 18 and thence to the discharge conduits 32 being recompressed by the compressor 34, and then, at an elevated temperature, being introduced into the steam manifolds 22, thus to serve as the heating medium for the elements 11.

Condensate discharge from the heating elements 11 flows outwardly of the casing through the manifold 24 to a condensate collecting tank 39, from which it is discharged through a valve 40 and a pipe 41 leading to a sump (not shown), the valve 40 being under the control of a level control device generally designated 42. Any gases entering tank 39 are discharged through a vent pipe 44. It is to be understood that, if desired, instead of steam a hot liquid may be employed as the medium to heat the heating elements 11.

Concentrated liquid remaining after the evaporation has taken place is collected, as seen at 45, in the pool in the bottom of the casing 14 and is withdrawn from such pool through a pipe 50 which leads to the intake port of a pump 51. Connected to the discharge port of pump 51 is a liquid product discharge pipe 46 in which there is interposed a valve 47 which is governed by a liquid level control device 49, whereby the level of the liquid product 45 is maintained substantially constant. A branch pipe 52 connected to the discharge pipe 46 of pump 51 in advance of valve 47 permits a certain amount of liquid to recirculate at a rate determined by the degree of opening of a valve 54 which is interposed in a pipe 52. Pipe 52 rises to near the top of the evaporator, where it turns to form pipe 56 which extends substantially throughout the length of the casing 14 above the row of heating elements 11.

Depending from pipe 56 within the casing 14 is a plurality of spray nozzles 57 which are so constructed and spaced as to subject the upper edges of the various heating elements 11 to a substantially uniform spray of liquid to be evaporated. The upper edge 59 of each of elements 11 is provided with inclined members forming a transverse central sharp edge so that the liquid from nozzles 57 flows downwardly along the outer surfaces of plates 12 in the form of continuous films. Feed liquor is introduced into the pipe line 52 through a pipe 60, which is connected to pipe 52 at a T-joint 63, and is mixed with any recirculating liquor passing the valve 54. It is preferable, however, to avoid recirculation, letting the feed liquor pass over the heating surface only once. This result may be achieved by having the valve 54 permanently completely closed during the operation of the system. The pipe 60 preferably has a throttling and shut-off valve 61 interposed therein, as shown.

As above noted, the evaporator 10^1 per se of Fig. 4 includes the same general combination of parts as that of Figs. 1, 2 and 3, above described with the exception of the horizontal or lengthwise extension of the casing, the corresponding lengthwise extension of the manifolds 22^1 and the spray pipe 56^1, and the provision of means $25,^1$ 29^1 whereby a plurality of separate heating elements, here indicated as three in number, may be added to the evaporator. The liquid distributing pipe 56^1 may also be made with the provision for the addition of one or more spray nozzles when required. In Fig. 4 the compressor 34, the feeding conduits 32 therefor, and the condensate discharge tank 39 with its attendant mechanisms have been omitted. The evaporator of Fig. 4 may, for example, be one of several effects of a multiple effect evaporator wherein the manifold 22 is fed either with heating steam or with vapor issuing from a previous effect, and the conduit 50, 52 discharges liquor to a further falling film evaporator effect for evaporation therein. As shown, closed spuds 25^1 and 29^1 are provided in the respective manifolds 22^1 and 24^1, and a capped spud or short pipe 58 is provided for the reception of a further spray nozzle 57, when required.

WHAT I CLAIM IS:—

1. An evaporator of the falling film type comprising a plurality of hollow heating elements each comprising two vertical, parallel plates and closed along its entire perimeter, the heating elements being disposed in a row extending perpendicularly to the parallel heating planes of the plates, and providing substantially plane heating surfaces, the confronting heating surfaces of successive heating elements being spaced to provide channels therebetween which are open at both vertical edges of said heating elements, means to supply a liquid to be evaporated to the outer surfaces of the heating elements at the upper edges thereof so that the liquid flows downwardly over the heating surfaces of the plates in the form of continuous films, means to introduce a heating fluid into and to exhaust it from the heating spaces within the heating elements, a casing enclosing the heating elements and the liquid supplying means, said casing providing a vapor body at each vertical edge of the

heating elements in free communication with the open edges of the respective channels, and means including a conduit opening into each vapor body at a position substantially below the upper ends of said channels for exhausting vapor released from the falling films of liquid from said vapor bodies and causing substantial lateral flow of said vapor out of said channels throughout the full height thereof into said vapor bodies.

2. An evaporator as claimed in Claim 1, wherein the heating elements are rigid pressure vessels directly mounted on the means for introducing a heating fluid into and exhausting it from the elements.

3. An evaporator as claimed in Claim 2, wherein the means for introducing a heating fluid into and exhausting it from the spaces within the heating elements comprises a first conduit means connected to the heating elements for introducing a heating vapor into said elements, and a second conduit means for removing condensate of the heating vapor from the bottoms of the heating elements, and readily separable means for connecting the heating elements to said conduit means, whereby the number of heating elements may be readily varied.

4. An evaporator as claimed in Claim 3, wherein the first conduit means comprises an elongated manifold disposed adjacent the top of the row of heating elements and in general alignment with such row, and the second conduit means comprises an elongated manifold disposed adjacent the bottom of the row of heating elements and in general alignment with such row, and wherein the readily separable means are disposed between the manifolds and the heating elements.

5. An evaporator of the falling film type substantially as hereinbefore described with reference to Figures, 1, 2, 3 and 5 or Fig. 4 of the accompanying drawings.

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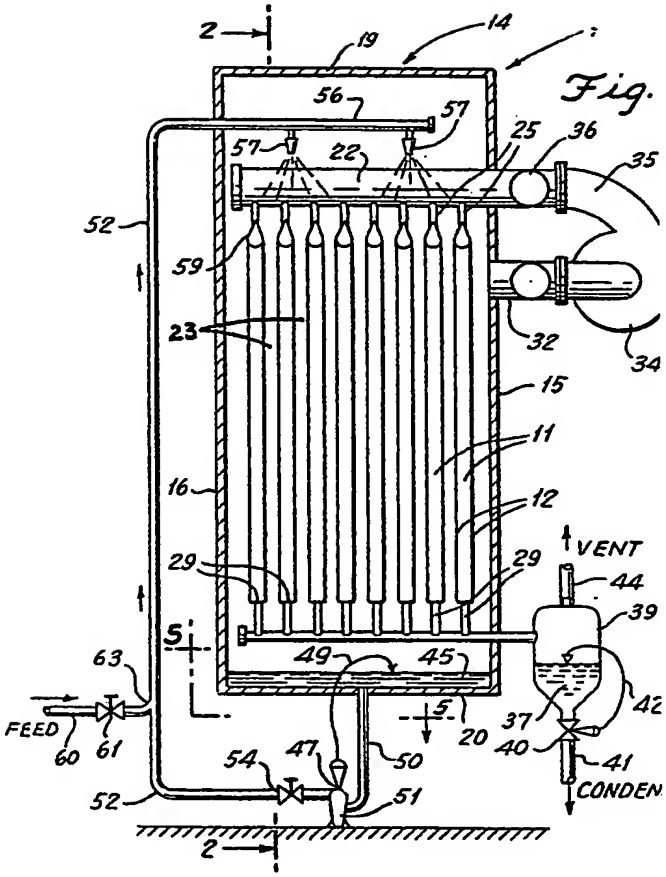
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Fig.

Fig. 1

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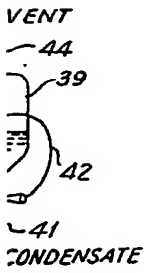
Fig. 1.



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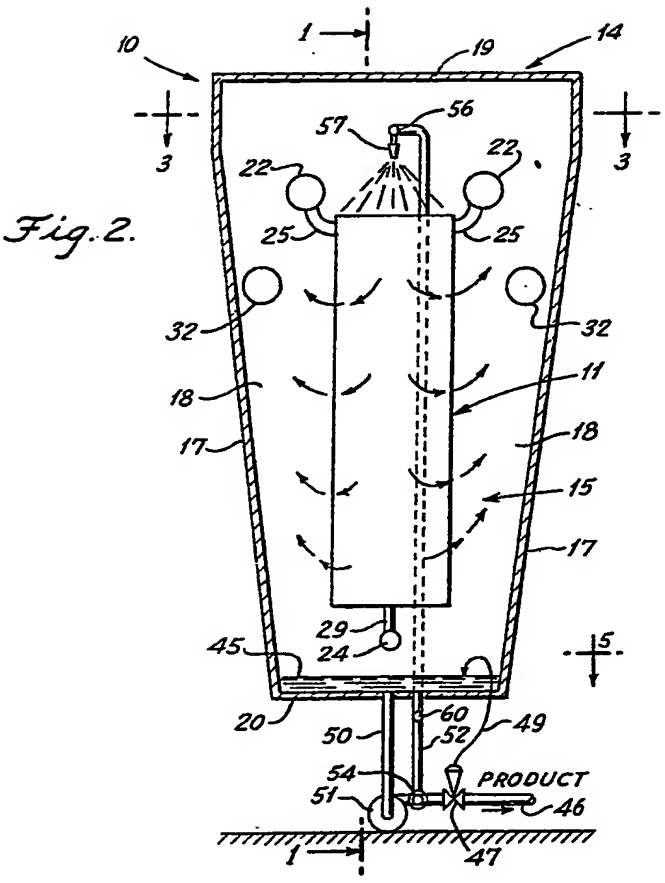

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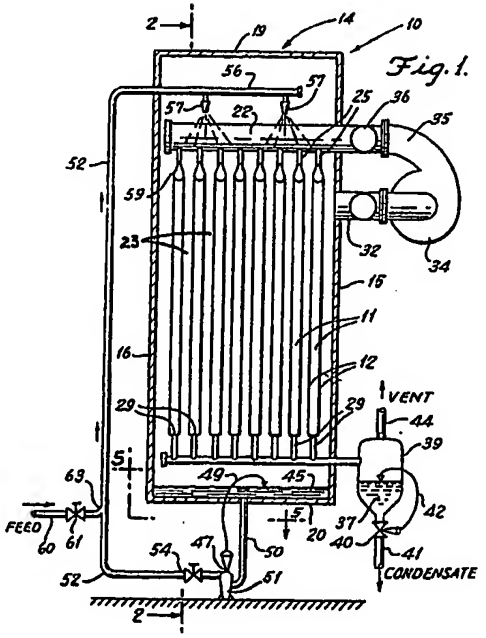

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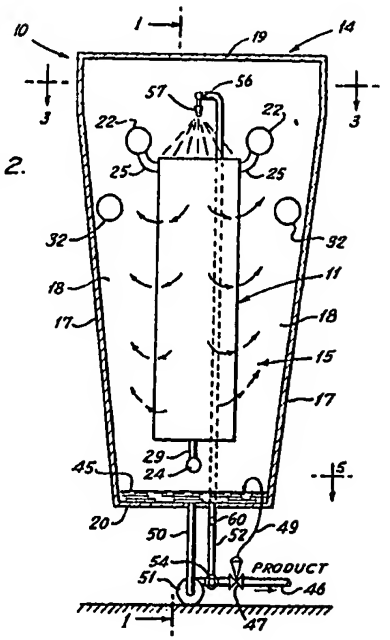

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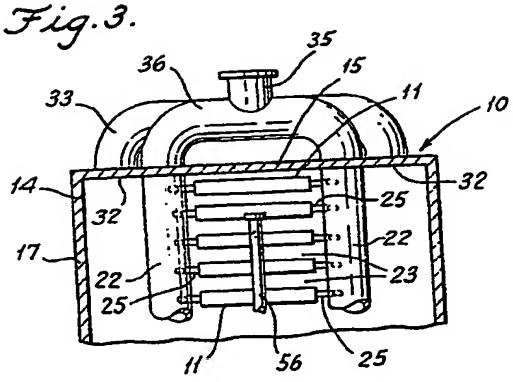
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Fig. 5.

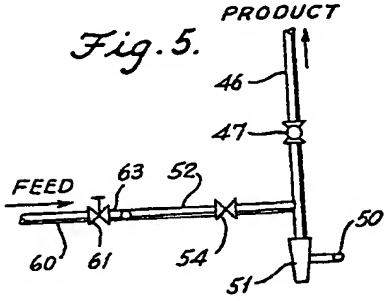
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Fig. 4.

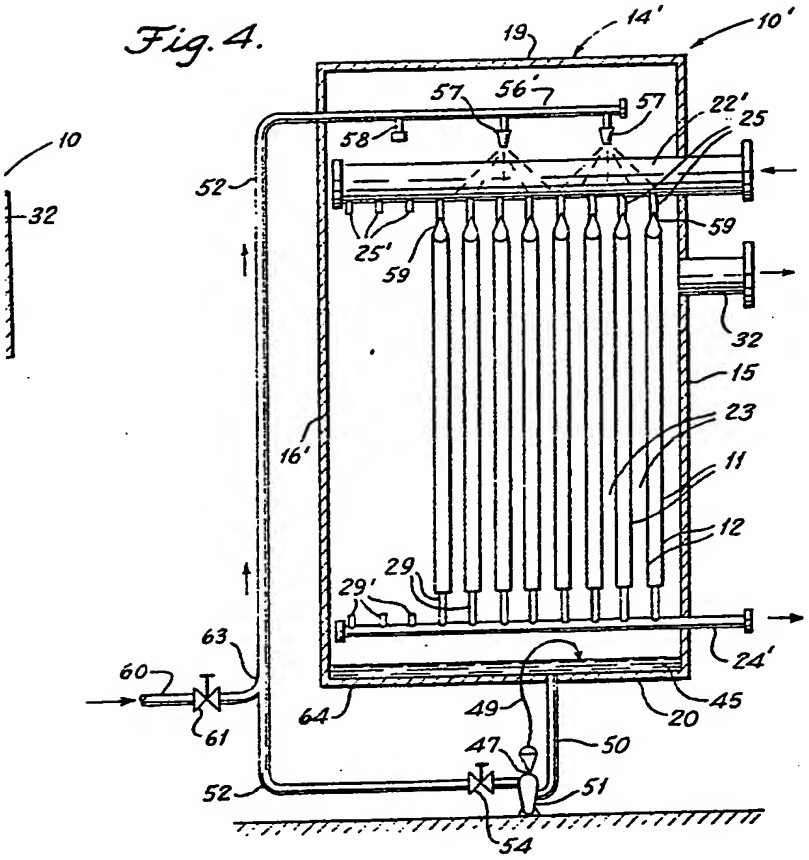

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Fig. 3.

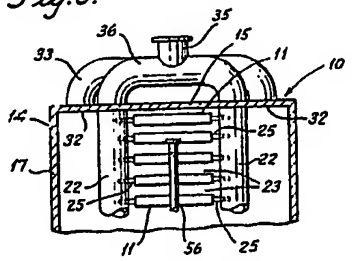


Fig. 5.

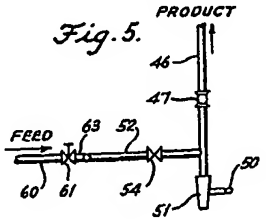
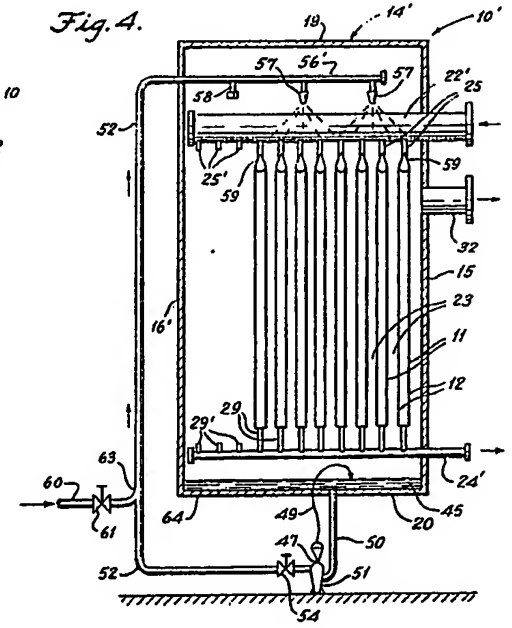


Fig. 4.



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